

# Identifying Spatial Efficiency–Equity Tradeoffs in Territorial Development Policies

Evidence from Uganda

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June 2009



## Abstract

In many countries, place specific investments in infrastructure are viewed as integral components of territorial development policies. *But are these policies fighting market forces of concentration? Or are they adding net value to the national economy by tapping underexploited resources?* This paper contributes to the debate on the spatial allocation of infrastructure investments by examining where these investments will generate the highest economic returns—“spatial efficiency”, and identifying whether there are tradeoffs when infrastructure coverage is made more equitable across regions—“spatial equity”. The empirical analysis focuses on Uganda and is based on estimating models of firm location choice, drawing on insights from the new economic geography literature. The main findings show that establishments in the manufacturing industry

gain from being in areas that offer a diverse mix of economic activities. In addition, availability of power supply, transport links connecting districts to markets, and the supply of skilled workers attract manufacturing activities. Combining all these factors gives a distinct advantage to existing agglomerations along leading areas around Kampala and Jinja. Infrastructure investments in these areas are likely to produce the highest returns compared with investments elsewhere. Public infrastructure investments in other locations are likely to attract fewer private investors, and will pose a spatial efficiencyequity tradeoff. To better integrate lagging regions with the national economy, lessons from the WDR2009 “Reshaping Economic Geography” calling for investments in health and education in lagging areas are likely to be more beneficial.

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This paper—a product of the Spatial and Local Development Team, Finance, Economics and Urban Development Department—is part of a larger effort in the department to examine the effectiveness of alternate strategies to integrate lagging and leading regions of countries. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The author may be contacted at [slall1@worldbank.org](mailto:slall1@worldbank.org).

*The Policy Research Working Paper Series disseminates the findings of work in progress to encourage the exchange of ideas about development issues. An objective of the series is to get the findings out quickly, even if the presentations are less than fully polished. The papers carry the names of the authors and should be cited accordingly. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the International Bank for Reconstruction and Development/World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the governments they represent.*

# **Identifying spatial efficiency–equity tradeoffs in territorial development policies: Evidence from Uganda<sup>1</sup>**

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## 1. Introduction

Greater concentration of economic activity in a few places is part of the spatial transformation that accompanies development. In fact, the main message of the World Bank's latest World Development Report "*Reshaping Economic Geography*" (WDR2009, World Bank 2008) is that economic growth will be geographically unbalanced, and trying to spread out economic activity is tantamount to discouraging it. On the other hand, living standards can spatially converge if policies facilitate economic integration – between lagging and leading places. And the WDR2009 identifies that investments to improve health, education and information in lagging areas along with efforts to encourage labor mobility are most effective for economic integration.

However, policymakers in many countries do not view increasing economic concentration as a beacon of progress. Rather, they actively try to stimulate economic growth in areas not favored by the market in an attempt to balance economic activity across the national territory. Place specific investments such as infrastructure to reduce transport costs and improve accessibility of peripheral regions are viewed as integral components of territorial development policies. *But are these policies fighting market forces of concentration? Or are they adding net value to the national economy by tapping underexploited resources?*

Answers to these questions are rarely reflected in spatial policy design— often because information on regional constraints to growth are limited and policymakers lack empirical evidence to inform their decisions. This paper contributes to the debate on the spatial allocation of infrastructure investments by examining *where* infrastructure investments will generate the highest economic returns – “spatial efficiency”, and identify if there are tradeoffs when infrastructure coverage is made more equitably across regions – “spatial equity”. To empirically identify spatial efficiency – equity tradeoffs, we examine the factors that entrepreneurs value when deciding where to locate

production facilities, and how these decisions are influenced by improvements in infrastructure linking specific regions to market centers.

The empirical analysis focuses on Uganda for two main reasons. First, the country's national economic policy calls for infrastructure improvements to accelerate national economic growth as well as develop a regionally balanced industrial landscape. Specifically, the National Industrial Policy identifies serious infrastructure shortfalls – particularly in electricity supply and transport as being binding constraints to growth, and also makes a case for infrastructure to support industrial parks in 21 towns throughout the country to create a national portfolio of industrial centers (GoU 2007). Identifying the implications of public investments in stimulating private investment in alternate locations can improve the sharpness of the infrastructure portfolio.

Second, the Ugandan national business registry provides spatially detailed information of firms providing detailed information on location and product lines of industrial firms in the country. The physical location of these firms is identified with considerable accuracy using GPS technologies. By combining economic analysis with geographically referenced data on placement of infrastructure (roads and electric grids), natural topography, as well as distribution of human capital across the country, we can concretely identify locations which generate the highest economic returns to public infrastructure investments.

Our empirical strategy is based on estimating models of firm location choice, and with analytic underpinnings based on the new economic geography literature that develops linkages between infrastructure development and agglomeration of economic activity.<sup>2</sup> In summary, if firms value scale economies from market access and external economies from agglomeration, then they are likely to concentrate production facilities. Infrastructure investments in these places can relieve congestion costs and attract further private investment. However, infrastructure investments may also try to promote spatial economic equity by improving access to remote areas. These investments may be

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<sup>2</sup> Baldwin et al (2005), Fujita et. al (1999), Puga (2002)

unsuccessful if the benefits they generate cannot offset the benefits that firms get from agglomeration. Thus, investments in remote areas may come at an opportunity cost to existing firms in dynamic areas – thereby creating a trade-off with national economic growth. Models developed in Baldwin et. al (2005) analytically show that in the presence of agglomeration effects, mobile firms are “locked-in” existing locations (and new ones are attracted to the same areas), thereby creating inertia in how firms respond to policies aimed at inducing relocation. The effects of infrastructure policies are likely to be insignificant until a threshold is crossed where the gains from relocation are higher than from staying.

Our analysis on identifying investment priorities using a new economic geography lens requires that we examine two specific questions. These are: (a) How much do infrastructure endowments matter when entrepreneurs make decisions on where to set up business establishments? (b) In comparison, do firms care about being physically close to other firms in the same line of business, or about locating in diverse economic environments? Once we know the relative valuation of infrastructure improvements and agglomeration economies for specific activities, we can identify returns to public investments in different locations.

Our main findings show that establishments in the manufacturing industry gain from being in areas that offer a diverse mix of economic activities. The economic geography literature points out that economic diversity, which is synonymous with urbanization economies, is associated with increased access to a broad range of producer and consumer services such as business, legal, and financial services. Typically, economic diversity increases with size of the agglomeration. In addition, availability of power supply, transport links connecting districts to markets, and the supply of skilled workers attracts manufacturing activities. Combining all these factors gives a distinct advantage to existing agglomerations. In Uganda, this means urban areas along Kampala and Jinja are likely to lead Uganda’s industrial development. Infrastructure investments that improve conditions for growth in these areas are likely to produce the highest returns compared to investments elsewhere. These should be high- priority public investment

locations as Ugandan policy makers consider policies for accelerating growth. Public infrastructure investments in other locations are likely to attract few private investors, and will pose a spatial efficiency – equity tradeoff.

Following this introduction, section 2 describes the data and clustering of manufacturing. Section 3 specifies the estimation model and variables, and discusses the findings from the empirical analysis. Section 4 provides alternate scenarios for transport improvements. Section 5 concludes.

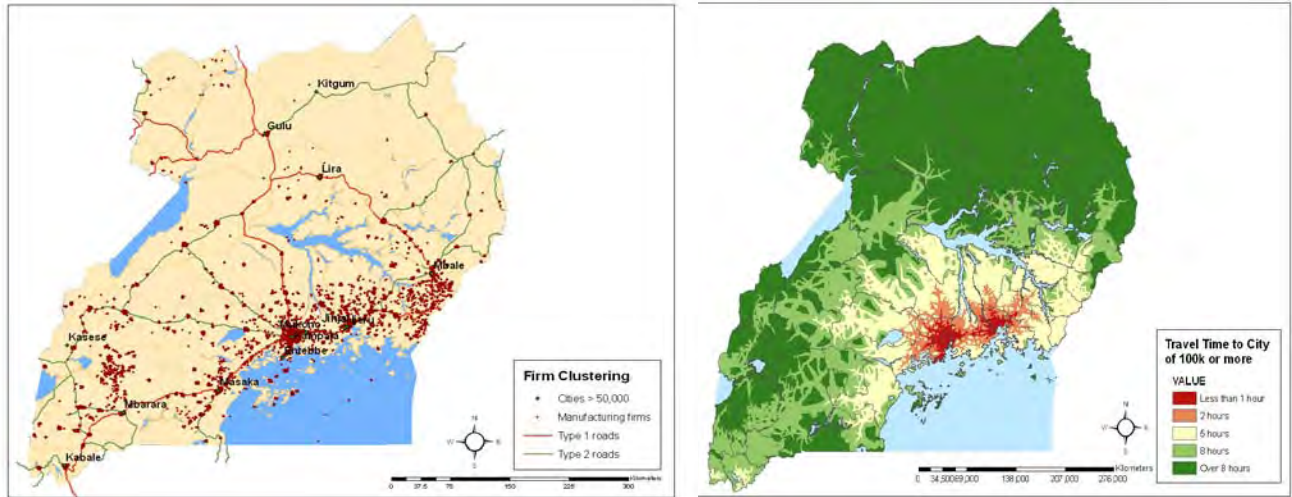
## **2. Clustering of industrial activity**

*Is industrial activity in Uganda located throughout the country?* No. Much of industrial activity is clustered around large cities and along transport corridors. Consider the map of industrial location in Uganda (figure 1). Mapping the location of industrial firms onto the country's geographic profile makes it clear that industrial activity in Uganda is concentrated (see the map on the left in figure 1). Most of the country's 12,000 manufacturing firms with 5 or more employees are clustered along the industrial corridor stretching between the country's major urban agglomerations—Masaka, Kampala, Jinja, and Mbale. Also clear is that the location of industrial activity closely follows the distribution of infrastructure networks. Seventy percent of the manufacturing firms with 5 or more employees are located within 10 kilometers of a major road. And, most of these firms are located in regions that are close to national markets, measured using travel times to cities of 100,000 or more (see the map below).

These manufacturing data are drawn from the Uganda Business Registry of 2001 which provides a comprehensive listing of all establishments in the country. A total of 165,000 establishments are included in this database. For each establishment, we know its physical location (measured by a GPS system), four-digit industrial classification, year that it started operations, and number of employees. The GPS coordinate provide each establishment with a unique location identifier (latitude and longitude) at accuracies of ten to fifteen meters. To our knowledge, the Uganda Business Registry is the only

nationally representative database in developing countries that has identified establishments with such accuracy.

**Figure 1 Spatial distribution of manufacturing firms and Access to markets in Uganda**



Using this database, we examine the extent to which manufacturing activity in Uganda is *localized* – i.e. concentrated across locations. Our data make it possible to examine distances between firms directly. In contrast, most establishment level data sets force researchers to analyze the data using administrative units as the units of observation. Often times, valuable information on localization is lost due to aggregation. Not surprisingly, commonly used measures of localization have been implemented with aggregate data in mind. Such examples are the Ellison-Glaeser (Ellison and Glaeser, 1997) and the location quotient (Isard 1956) indices.

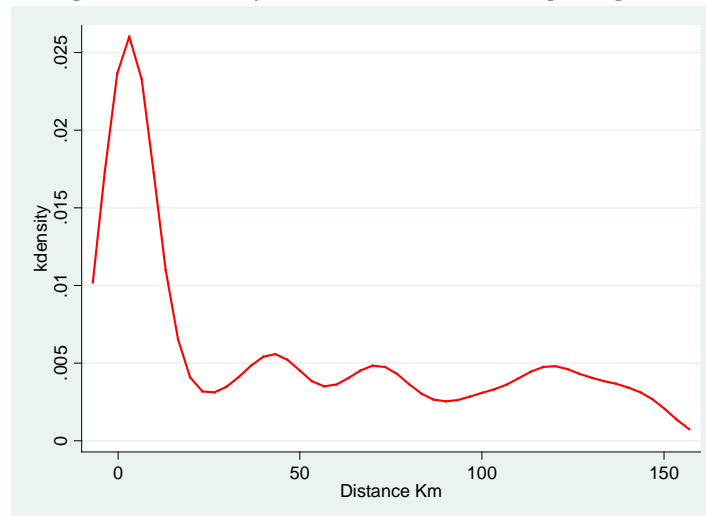
To exploit the unique feature of our dataset, we calculate establishment-to-establishment distances for all manufacturing and specific industries. This is similar to the procedure employed by Duranton and Overman (2005) where they set up a measure

to examine localization using micro geographic data.<sup>3</sup> We start by calculating the Euclidian distance between every pair of manufacturing establishments. For manufacturing industry  $M$  with  $n$  establishments, this generates  $n(n-1)/2$  unique distances between establishments. We then calculate the frequency for each distance level and plot the corresponding density. We can represent the Euclidian distance between establishments  $i$  and  $j$  by  $D(i,j)$ , and define  $\delta(i,j,d)$  such that  $\delta(i,j,d) = 1$  when  $D(i,j) = d$  and  $\delta(i,j,d) = 0$  otherwise. The un-smoothed distance density or  $K$ -density is:

$$K_M(d) \equiv \sum_{i=1}^{n-1} \sum_{j=i+1}^n \frac{\delta(i,j,d)}{n(n-1)}$$

For overall manufacturing, we find small distances between establishments. A third of all manufacturing firms are within 3.7 kilometers of each other; 45 percent are within 9 kilometers, and the 50<sup>th</sup> percentile is 41.5 kilometers. The distribution of overall distances is shown in figure 2. The distribution shows a kernel density of distances, which is plotted using the Gaussian kernel specification in STATA.

**Figure 2: K density of overall manufacturing in Uganda**



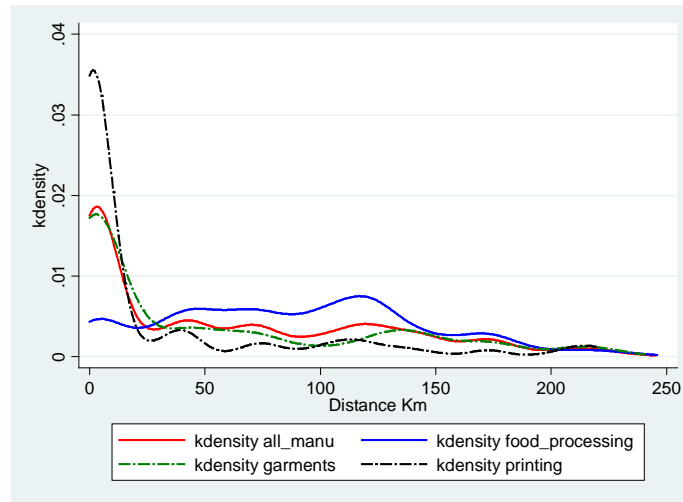
We also looked at specific industries to examine the extent to which firms were clustered. For instance, for establishments in paper and printing (SIC 222), the 50<sup>th</sup> percentile of inter-establishment distance is 1.8 kilometers, signifying that the industry is

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<sup>3</sup> At this time, we have not compared the distribution of sector specific concentrations to a counterfactual random distribution of establishments, using all manufacturing locations as the universe of location possibilities. We will be providing this comparison in subsequent work.

much more localized relative to manufacturing as a whole. In comparison, the 50<sup>th</sup> percentile of inter-establishment distances for garments (SIC 181) is 9 kilometers, and 89 kilometers for food processing (SIC 153). The distributions of inter establishment distances are show in figure 3. The descriptive statistics in this section have shown that manufacturing activity is clustered.

**Figure 3: Comparing clustering across industries**



### 3. Modeling location decisions of manufacturing firms

The clustering of establishments raises an important policy question – are firms clustering because they are constrained in their location choice by a need to be near sparse infrastructure networks, or are there gains from exploiting agglomeration economies? If it is the former, then policies such as transport and electricity network expansion (lower transport and production costs in the peripheral regions) can allow firms to move to lower cost locations and still access markets. If agglomeration economies dominate, then it may be useful to improve infrastructure services in congested areas to maximize positive spillovers associated with industrial development.

In making decisions of where to set up businesses, entrepreneurs are most likely to select areas that offer conditions where profits can be maximized. Prices and quality of inputs, prices of outputs and access to technology matter. Firms are likely to cluster in areas that provide *good access to markets* as the size of the market influences the firm’s decision to increase scale and invest in cost reducing technologies. Firms may also be

attracted to areas that already have firms established in their lines of business – *localization economies*. Why? Because new firms can learn from existing ones about business processes, new technologies and informal regulations, as well as benefit from a pool of trained workers. Finally, firms may value the overall economic diversity of an area. These are often referred to as *urbanization economies*, and are associated with good access to a broad range of producer and consumer goods that typically increase with size of the agglomeration.

A recent paper surveying industrial location decisions in developing countries identifies the following factors as being important (Deichmann et. al 2008). These are:

- Factor prices.
- Quality and cost of complementary utility services, including electricity, water and telecommunication.
- Market access as a function of the size of the region that can be reached given existing transport infrastructure.
- Agglomeration economies as measured by the presence of firms in own industry and of firms in related—e.g., buying or supplying—industries.
- Labor and other regulations.

In many of the papers covered in the survey, benefits of agglomeration economies (both own industry and overall diversity), market access and infrastructure endowments outweigh the costs imposed by congestion, increasing wages and land prices (Deichmann et. al 2008). Using firm survey data from India, Lall and Mengistae (2005) find that localization economies, as measured by own industry concentration, have significant bearing on firm location decisions across cities. This effect is the highest for technology intensive sectors. Deichmann et al. (2005) find similar evidence for manufacturing firms in Indonesia. Localization effects are more important for high-technology (e.g., office computing) and natural resource-based industries (such as wood or rubber and plastic).

Empirical work on urbanization economies is mixed. Empirical studies for the United States by Bostic (1997), Garcia-Mila and McGuire (1993), and Glaeser et. al (1992) show that diversity in economic activity has positive impacts on regional economic growth. On the other hand, also using data for the United States, Mirachy

(1995) finds little evidence to support the diversity argument. For India, Lall et al. (2003) find evidence that diversity is the most important source of external cost reduction for Indian manufacturing establishments. Their analysis is based on estimating cost functions with micro data for specific manufacturing industries.

For Indonesia, Henderson et al. (1995) show that the relative importance of urbanization economies is higher in new high-tech industries compared to mature capital goods industries. These findings are consistent with product cycle theory (Vernon 1966) and insights from work on “nursery cities” (Duranton and Puga 2001), which predict that new industries tend to prosper in large and diverse urban areas, but with maturity, their production facilities move to smaller and less diverse cities.

We estimate a location choice model to understand the main factors that influence decisions of entrepreneurs to establish manufacturing establishments across areas of the country. From the previous section, we know that manufacturing overall is clustered – but we want to know if clustering is due to benefits from localization economies, or driven by transport links that connect areas to markets, availability of complementary production inputs such as electricity, the quality of the local labor force, or the benefits from being in a diverse economic environment. Ugandan manufacturing is not technology-intensive or innovation-led. It is dominated by production activities that are standardized and require low technology by global standards. These include food processing, garments and textiles, clay products and furniture. However, many of these products and business lines are new to the country, so they can be considered locally as “sunrise” activities, while being “sunset” activities globally.

### *Estimation strategy*

To examine location decisions of firms, we specify a profit function where an establishment will be located in a particular region if the profits from being there are higher than profits in any other region of the country. This model is an adaptation of the Bayer and Timmins (2007) equilibrium model of location choice to the question of industrial development. In the model, profits  $\pi$  earned by establishment  $i$ , in industry  $k$ , which chooses to locate in region  $j$  are:

$$\pi_{i,j,k} = f(\sigma_{j,k}, A_j, IR_j, LIN_j, H_j, X_j, \eta_{i,j,k}; \bar{\beta}_k) \quad (1)$$

Agglomeration effects that provide production externalities are represented by  $\sigma_{j,k}$  (localization economies), measured as the own-industry concentration of industry  $i$  in region  $j$ ;  $A_j$  represents externalities from urbanization economies (measured by industry diversity);  $IR_j$  refers to the quality and availability of inter regional infrastructure that links the region to market centers;  $LIN_j$  reflects local infrastructure conditions in the region –such as power supply;  $H_j$  represents the region-specific stock of human capital.  $X_j$  includes region-specific natural geography conditions, which include ruggedness of the region’s terrain, natural resources to support development, and climate (rainfall). Good natural geography (“first advantage” in the expression used by Burgess and Venables (2004)) is likely to stimulate early period population growth and economic development, and neglecting these factors could provide misleading effects of economic geography variables (market access, agglomeration economies).

We choose the following functional form for this profit function:

$$\pi_{i,j,k} = \beta_{0,j} + \beta\sigma_{j,k} + \beta A_j + \beta IR_j + \beta LIN_j + \beta H_j + \beta X_j + \eta_{j,k} \quad (2)$$

The  $i$ th firm will choose region  $j$  if  $\pi_j^i \geq \pi_l^i$  for all  $l$ , where  $l$  indexes all the possible region choices to  $i$ th firm. For estimation we will assume that  $\eta_{i,j}$  is additively separable from the rest of the utility function, and has a Weibull distribution. The result is that we can write the probability that any firm will choose to locate in region  $j$  [McFadden, 1973]:

$$P(\pi_{i,j} \geq \pi_{i,l} \quad \forall l \neq j) = \frac{e^{\beta_{0,j} + \beta\sigma_{j,k} + \beta A_j + \beta IR_j + \beta LIN_j + \beta H_j + \beta X_j}}{\sum_{l=1}^J e^{\beta_{0,l} + \beta\sigma_{l,k} + \beta A_l + \beta IR_l + \beta LIN_l + \beta H_l + \beta X_l}} \quad (3)$$

In our estimation, we are assuming that each firm takes attributes associated with each region as given and makes rational location choice decisions. For the purpose of estimation, this assumption translates into a condition where the idiosyncratic error term is independent of the regional characteristics. One of the main empirical challenges in separately identifying the effects of local spillovers (i.e. localization economies) is that the concentration of firms in location  $j$  may be correlated to sources of natural advantage that are not observed in the data. If favorable natural conditions encouraged or facilitated concentration of firms in particular areas, then not addressing this correlation is likely to overstate the impact of agglomeration economies.

A standard solution for this omitted variable problem would be to employ instrumental variables. However, we use a conditional logit model to estimate equation (3), which implies that we cannot use instrumental variables. To address this problem within our estimation framework, we only analyze location decisions of firms who have started business in the four years preceding the survey. Next, we create agglomeration variables using data for establishments that were in business five or more years before the survey. By splitting the data, we hope that unobserved characteristics that matter for today's location decisions are different from those that influenced previous concentration. Our second strategy is to include a range of variables representing sources of "first advantage" directly into the estimation. These variables are described earlier and should capture why some areas became attractive for people and establishments in the first place.

*Variable construction:*

Infrastructure for market access: We computed travel times on the road network from each GIS pixel in the country to the nearest city of 100,000 or more people. In order to extract these data, we built a raster dataset at a 500 meter resolution where each pixel records the time in tens of minutes to travel from the specific pixel (year 2000 estimate from GRUMP alpha data). Travel time is estimated using a combination of several GIS layers that are merged into a friction grid which represents the time required to cross each pixel (each pixel represents 500m<sup>2</sup>). As the pixel friction value increases, the travel time to the nearest city of 100,000 increases as well.

The underlying road database is based on the Digital Chart of the World (DCW), which was expanded using attributes from Michelin 2004 regional maps to distinguish among primary, secondary, and tertiary roads.<sup>4</sup> In addition, further refinements to these maps were made through a Uganda national roads dataset in order to allow for more precise analysis. This database was then layered with various GPS data in order to extract travel time and distance from major cities.

Power supply: A dummy variable showing the presence of an electric grid in district is used to proxy for access to power supply. This is a crude measure, but we could not obtain data on actual usage or reliability of power supply.

Localization: There are several ways of measuring localization. These include own-industry employment in the region, own-industry establishments in the region, or an index of concentration, which reflects disproportionately high concentration of the industry in the region in comparison to the nation. We use own-industry establishments as the measure of choice as we want to test if there are gain from locating in areas that are already specialized in the firm's chosen line of business. Also, when location "shopping" entrepreneurs are more likely to observe the density of establishments in an area, compared to the number of people employed in them. Using the number of firms in the same sector has also been commonly used in empirical work, with the underlying premise that localization economies come from the absolute volume of similar activities in the neighborhood.

For the localization measure, we consider the number of establishments in the same 2 digit industry sector who are within 20 kilometers of each firm under consideration.<sup>5</sup> As discussed earlier, we only use establishments that have been in business for more than 5 years for this calculation. For the location modeling, we then average these numbers at the district level.

Economic diversity (urbanization economies): We use a region's economic diversity to reflect potential gains from urbanization economies. Typically, larger cities have a greater diversity of firms (Deichmann et. al 2008). This allows greater

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<sup>4</sup> Thomas (2007) assigns travel along primary roads to be 60km/hr, secondary roads 40km/hr, and tertiary roads 20km/hr.

<sup>5</sup> We also tried localization measures with 5Km and 60Km, and in general found that agglomeration economies are higher at closer distances.

specialization since it enables small, innovative firms to access a larger pool of potential buyers and complementary services that cannot be provided in-house. Larger cities also provide a larger home market for end products, make it easier to attract skilled employees who are attracted by urban amenities not available in smaller towns, and support a large number of complementary service providers such as financial and legal advisers, advertising and real estate services.

The well-known Herfindahl measure is used to examine the degree of economic diversity in each district. The Herfindahl index of a district  $j$  ( $H_j$ ) is the sum of squares of employment shares of all industries in district  $j$ :

$$H_j = \sum_k \left( \frac{E_{kj}}{E_j} \right)^2 \quad (4)$$

Unlike measures of specialization, which focus on one industry, the diversity index considers the industry mix of the entire regional economy. The largest value for  $H_j$  is 1 when the entire regional economy is dominated by a single industry. Thus a higher value signifies lower level of economic diversity. Therefore, for more intuitive interpretation of the measure, for the diversity index in our model,  $H_j$  is subtracted from unity. Therefore,  $DV_j = 1 - H_j$ . A higher value of  $DV_j$  signifies that the regional economy is relatively more diversified.

Variables on district specific characteristics were computed from various sources. The human capital variable reflects the share of each district's working age population with primary school or higher education. This comes from the 2002 Uganda Census. Other variables such as terrain roughness were derived from USGS/NASA SRTM data. In order to analyze roughness per district, these data were aggregated into 100 by 100 groups of cells (approximately 10 km by 10 km). For each aggregation, a mean was computed in order to determine overall elevation variability within a district (Thomas, 2007). In addition, we were also able to disaggregate major crop production by district using a Spatial Allocation Model (SPAM) developed by IFPRI (see You et al., 2007 and You, Wood and Wood-Sichra, 2007). The complete list of data sources are provided in the Appendix.

*Main findings:*

The sample for estimating the location choice model includes all firms in the Uganda Business Registry that have more than five employees and that were less than five years old at the beginning of the survey. We limit the sample to relatively new entrants to address the concern that older firms may have made location decisions facing considerably different location attribute choices. There are 56 districts (using 2002 definitions) that firms can choose among in Uganda. In general, the model performs very well in predicting where establishments will be located. Based on the model parameters, our success in predicting actual location decisions is 98 percent. Table 1 provides the raw estimates and standard errors from the conditional logit model. Column 1 reports estimates for all manufacturing firms. Columns 2-8 provide sector specific estimates. These sectors are: Food and beverages, textiles and apparel, paper and printing, chemicals and petroleum, rubber and plastics, metal products and furniture.

Infrastructure: We find that access to the power grid has a positive effect on a district's attractiveness for location of manufacturing activity.<sup>6</sup> These results are significant in estimations for all manufacturing. While the estimates are positive for each of the industry sectors, it is statistically significant for food and beverages, garments and textiles, and furniture industries. Remember that our measure of power supply is a crude one – we only have information on whether or not the power grid runs through the district. It would be useful to collect information on power breakdowns and prices for future analysis.

Market access, measured by transport connectivity to cities of 100,000 or more people is an important factor in determining industry location. Remoteness from market centers lowers industrial prospects. Estimates for pooled estimates of all manufacturing industries produce statistically significant effects. For specific industries, establishments in food and beverages, and chemicals and petroleum products value market access (after controlling for the other variables). Estimates for other sectors are not statistically significant.

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<sup>6</sup> Similar findings are also obtained in analysis of location decisions of Indian manufacturing (Lall and Mengistae 2005, Mani et. al 1997).

Agglomeration: Given the extent of clustering seen in the data, one would expect that the presence of own-industry concentration would directly influence location choices. This is correct when we use the localization variable as the only determinant of industry location. However when we control for other factors, the localization variable has a negative effect on location decisions in models using all manufacturing establishments in the estimation. This would imply that competition and prices of fixed production factors increase with industry agglomeration – and would make clustered locations more expensive. However, results for individual sectors exhibit considerable heterogeneity. The effects of localization are positive and significant for establishments in food and beverages, chemicals, rubber and plastics, metals and furniture industries. However, for the paper and printing industries, localization economies have a negative effect on location choices. Given these mixed signals from localization industries, why do establishments concentrate production facilities?

The answer to this puzzle is in positive economies that establishments accrue from economic diversity. The estimates of economic diversity for all manufacturing as well as specific industries are positive and significant. The only exception is chemical and petroleum products, where the estimate is not statistically significant. These results tell us that entrepreneurs locate establishments in areas that offer a diverse range of economic activities. In the economics literature, there are three main reasons that explain the importance of economic diversity: (1) information sharing and innovation – large cities are breeding grounds for new ideas and innovations due to the concentration and diversity of knowledge sources. This facilitates product and process innovation, and therefore new products are more likely to be developed in diversified cities (Duranton and Puga 2001); (2) establishments located in large cities have relatively better access to producer amenities such as business services, finance, logistics, banking, advertising, and legal services – which can enhance economic performance (Abdel-Rehman 1988, Fujita 1988, Rivera Batiz 1988); and (3) on the consumption side, increasing the range of local goods enhances welfare of households. Thus, economic diversity can yield external scale economies through the variety of consumer and producer goods.

**Table 1: 'Raw' estimates from conditional logit estimation**

	All manufacturing	Food and Beverages	Textiles and apparel	Paper and printing	Chemicals and Petroleum	Rubber and plastics	Metal products	Furniture
<b>Infrastructure</b>								
Market Access	-0.0008 [0.0003]**	-0.0012 [0.0007]*	0.0016 [0.0012]	-0.0002 [0.0017]	-0.0417 [0.0193]**	0.0007 [0.0019]	0.0021 [0.0022]	-0.0011 [0.0007]
Electric grid	1.5043 [0.2846]***	2.3627 [0.7139]***	1.8944 [1.0224]*	12.7944 [386.6443]	13.4268 [1059.9987]	15.5558 [1197.6892]	13.7753 [345.9622]	0.6305 [0.3322]*
<b>Agglomeration</b>								
Localization	-0.0007 [0.0002]***	0.0107 [0.0025]***	-0.0001 [0.0006]	-0.0757 [0.0235]***	0.7126 [0.3422]**	0.1058 [0.0178]***	0.0043 [0.0024]*	0.0037 [0.0009]***
Diversity index	2.5932 [0.2546]***	2.9509 [0.4087]***	2.4040 [0.9135]***	3.0168 [1.1395]***	0.4531 [3.996]	4.7781 [1.1240]***	3.4196 [0.8113]***	1.2262 [0.4811]**
<b>Human Capital</b>								
Education	14.0667 [0.4061]***	5.5984 [1.3373]***	14.1216 [1.6408]***	26.4592 [2.8674]***	-14.6166 [14.0647]	4.9415 [2.1058]**	13.0636 [2.6103]***	3.9464 [1.9758]**
<b>Natural Geography</b>								
Roughness	-0.0005 [0.0002]***	-0.0004 [0.0003]	-0.0012 [0.0006]*	0.0002 [0.0005]	0.0066 [0.0026]**	-0.0008 [0.0009]	-0.0015 [0.0006]**	0.0002 [0.0002]
++++Other controls: yields of coffee, cotton and maize								
Observations	86562	28998	6642	8964	2322	4482	12150	21654

Standard errors in brackets

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Estimates were bootstrapped 1000 times to produce confidence bands.

Human capital: We find that the availability of workers who have primary or more schooling has a considerable impact on location decisions in manufacturing industries. The only exception is the chemical and petroleum industry where the effects are not statistically significant. In general terms, a pool of semi skilled workers makes it easier for firms to scale up production by hiring more workers. In fact, investment climate surveys in many developing countries identify the lack of skilled workers as being a major impediment to increasing firm size and productivity.

#### **4. Geographically prioritizing infrastructure investments**

##### *Identifying high return areas*

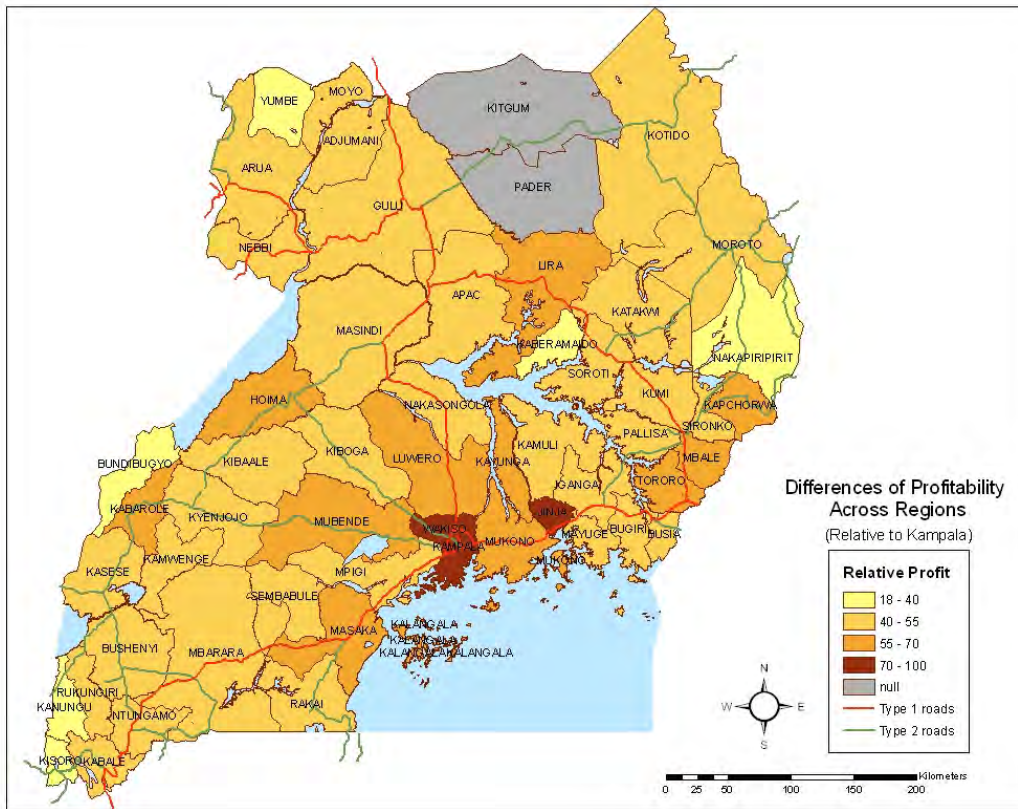
We now move from describing the empirical analysis of location choices to identifying *where* public infrastructure investments will produce the highest economic returns in terms of national industrial promotion. Addressing this policy concern requires that we recall how firms in various sectors value district specific endowments. In particular, agglomeration economies – from economic diversity are important location determinants. As firm performance depends on being located in a diverse and large urban environment, it is extremely difficult for policies to successfully move and sustain these activities in secondary locations. This is because successful relocation policies will need to coordinate decisions of firms across sectors. In addition, the stock of human capital is important for location decisions of manufacturing establishments.

At least in the short-to-medium term, these ‘preconditions’ are likely to be fixed, and the effects of infrastructure improvements will depend on the relative ‘stock’ of these attributes across districts. For example, consider education attainment. 421,000 people of working age in Kampala have completed primary or higher education. In comparison the ‘human - capital’ stock in Lira is 92,000 and 56,700 in Gulu. Other things being equal, for industries that value skilled labor, Kampala becomes more attractive than upcountry centers.

Firms consider a package of amenities that a region offers in making location decisions. From our model, we can predict the relative profitability to manufacturing

firms across districts.<sup>7</sup> Figure 4 plots these values, where each district's 'profitability' is compared to Kampala, which is normalized at 100. From this figure it is clear that expected profits are highest in Kampala, Wakiso and Jinja. These are high return areas for private manufacturing. Districts at the borders of these agglomerations and those along the road leading to the Kenyan border also offer profitable opportunities for manufacturing. Appendix 2 lists these relative profits.

**Figure 4: Relative profits for manufacturing firms across districts<sup>a</sup>**



a. Profitability is compared relative to Kampala, which is normalized to 100

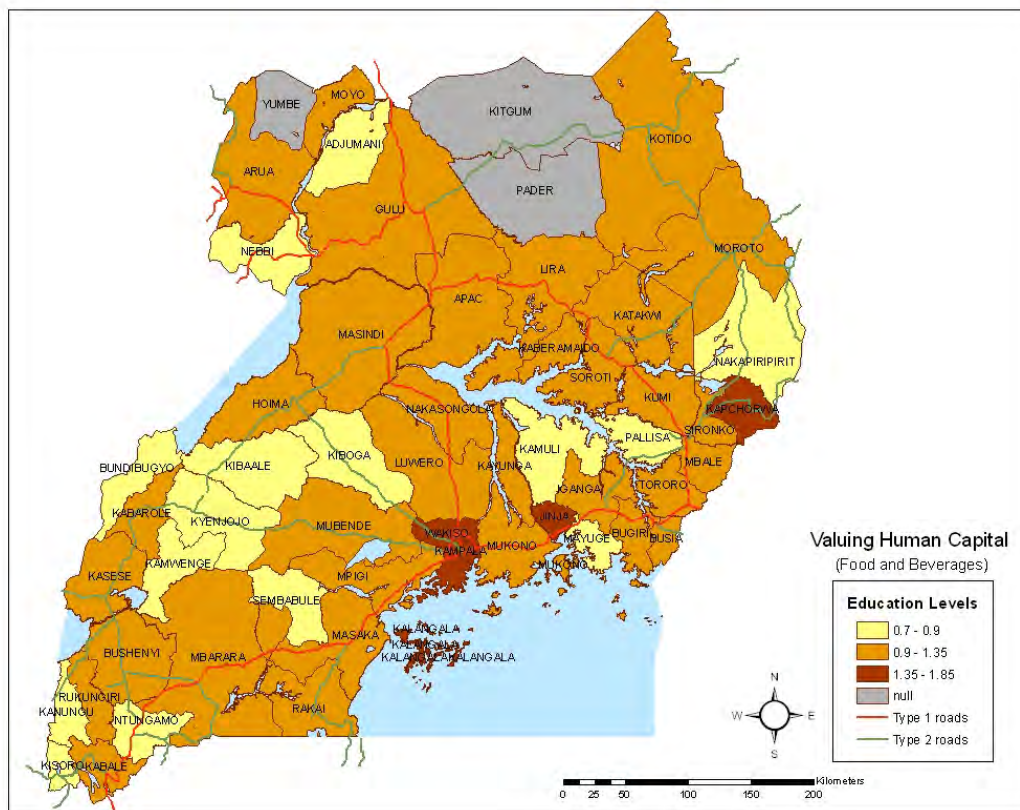
In addition to overall profits, we can also calculate how specific attributes contribute to profitability differences. The effect of any particular attribute  $x_{jm}$ , on the probability that a firm locates in district  $j$  is given by

<sup>7</sup> Using the functional form in equation (2)

$$\frac{\partial \ln P_j}{\partial \ln x_{j,m}} = \beta_m x_{j,m} (1 - P_j) \quad (5)$$

where  $\beta_m$  is the parameter estimate from the clogit model, and  $P_j$  is the probability of firm location in district  $j$ . Consider for example, the returns to human capital across districts for establishments in the food and beverages industry (figure 5), which are relatively higher in the Kampala region.

**Figure 5: Importance of human capital for the food and beverage industry**



### *Geographically prioritizing infrastructure improvements*

Given the distribution of relative profits and the ‘preconditions’ for success, where will infrastructure investments produce the highest returns? To examine this question, we simulate road improvements in two locations:

- In the first case, we simulate improvements of road conditions around the Northern cities of Gulu and Lira to increase travel speeds from 60 to 100

km/h. This would reduce the time it takes to travel from these cities to market centers of 100,000 people from an average of 5 hours to 3 hours.

- In the second case, we simulate improvements of roads around high profit cities— Iganga, Mpigi and Mubende, which are in the country’s main industrial agglomeration. Again these road improvements are assumed to increase travel speeds from 60 to 100 km/h.

We focus on road improvements as this is the most important modes of transportation in the country. The World Bank’s Country Economic Memorandum (World Bank 2006) for Uganda identifies that improvements in the national road network are extremely relevant for Uganda’s economic growth given their strategic functions, relative high usage (they carry most of Ugandan traffic) and thus –in practice—their yielding of highest social returns to capital. In terms of usage, national roads account for 15 percent of the network but carry about 80 percent of the total traffic. Further, the paved segments of the national network experiences greatest traffic and usage. In 2003, the 25% paved length of the national network carried 70% of the vehicle-kilometers. On average, paved roads carried 2670 vehicles per day, while unpaved roads carried only 346; 91% of the paved national roads and 26% of the unpaved national roads carried more than 500 vehicles per day.

In our model, improving roads would have two effects. First, it would increase access to markets, and second it would increase the spatial extent of agglomeration economies as firms can effectively be ‘closer’ to a larger number of firms in their industry. We use firms in the food and beverages industry to calibrate the simulation. The location choice model shows that agglomeration economies and infrastructure are both important factors. We find that these improvements only provide modest gains for industry location in the Northern districts of Gulu and Lira. In Gulu, the share of national food and beverage establishments increases from 1.7 percent to 2 percent. In Lira, it moves from 1.9 to 2.3%.

In comparison, in Iganga district that adjoins Kampala, transport improvements increase the share of establishments that would locate in the district from 5.8 percent to 10.5 percent. However, there are only small gains from additional investments in Mpigi

and Mubende. Overall we find that the “pull” of agglomeration economies is strong and reduces the impact of complementary investments to decentralize manufacturing activity.

This simple simulation exercise uses results from the empirical analysis and identifies that private returns to public infrastructure investments, measured by new industrial development, is highest in areas that offer “preconditions” for success. In particular, the stock of human capital and an existing mix of diverse economic activities are important ingredients in a successful growth “recipe”. Incidentally, these preconditions are offered in the country’s main urban agglomerations.

## **5. Conclusion**

In this paper we find that entrepreneurs in Uganda value agglomeration economies, human capital, and infrastructure conditions in deciding where to locate manufacturing establishments. The effects of infrastructure improvements to promote industrial development and accelerate national economic performance are highest in areas that offer external scale economies from agglomeration and availability of skilled workers. These ‘preconditions’ are relatively abundant in main urban agglomerations of the country – thus, improving infrastructure in these places provides the highest private return to public investment. On the other hand, using infrastructure to support economic growth in areas which are deficient in these ‘preconditions’ is likely to yield low returns. Investments to link peripheral regions to markets are also likely to be more expensive in absolute terms. Policymakers should consider these spatial efficiency-equity tradeoffs in deciding the spatial allocation of infrastructure investment.

The results from the location choice analysis are consistent with very detailed cost benefit analyses of transport improvement projects in Uganda (World Bank 2004). The World Bank’s HDM model allows for the modeling, through time, of the interaction between traffic volume and composition, and road condition and vehicle operating costs. The cost benefit analysis using the HDM model shows that the net present value (NPV) of improving 67Kms of roads between Kampala - Gayaza- Zirobwe-Wobulenzi, connecting the capital to agriculture rich areas was US\$23.3million. In comparison, improving 114 Kms of roads between the Northeastern towns of Soroti and Lira produced a NPV of US\$9.9million.

At an annual average of US\$21 per capita, current infrastructure spending in Uganda is extremely low given the current state of infrastructure services (Briceno-Garmendia 2006). These levels are half the lowest annual average per-capita amount spent in Latin American countries at the end of the 90s and they are only comparable to what Indonesia was spending in infrastructure right after the financial crisis. There is urgent need to scale up infrastructure investments.

However, infrastructure investment decisions need to be made in a way that responds to the country's development objectives at the lowest possible cost. If, as reflected in Uganda's National Industrial Policy (GoU 2007), industrial development is the cornerstone of the country's accelerated growth strategy, then infrastructure investments need to be prioritized towards modes and geographic areas that can produce the highest returns in terms of industrial development. The analysis in this paper provides one approach for prioritizing these investments.

## References:

- Abdel-Rahman, H. (1988). Product differentiation, monopolistic competition, and city size. *Regional Science and Urban Economics*, 18, 69-86.
- Baldwin, R., R. Forslid, P. Martin, G. Ottaviano, and F. Robert-Nicoud (2005) *Economic Geography and Public Policy*. Princeton University Press
- Bayer, P and C. Timmins (2007) "Estimating Equilibrium Models of Sorting Across Locations," *Economic Journal*, March 2007.
- Bostic, R. 1997. "Urban productivity and factor growth in the late 19th century." *Journal of Urban Economics* 4:38-55.
- Briceno-Garmendia, C. (2006). Uganda - Infrastructure for Growth. Contribution to Uganda Country Economic Memorandum, World Bank.
- Burgess, R. and A. J. Venables. (2004). "Towards a microeconomics of growth." In: Bourguignon F. and B. Pleskovic (Eds.). *Annual World Bank Conference on Development Economics 2004: Accelerating Development (Bangalore conference proceedings)*. World Bank: Washington DC.
- Deichmann, U, S.V. Lall, S. Redding, and A.J. Venables (2008). Industrial location in developing countries. *World Bank Research Observer*.
- de la Fuente, A. And X. Vives (1995), "Infrastructure and education as instruments of economic policy: Evidence from Spain", *Economic Policy*, No 20, April
- Duranton, G. and H. Overman (2005). "Testing for Localization Using Micro-Geographic Data", *Review of Economic Studies*, 72(4) 1077-1106,
- Duranton, G., and D. Puga (2001). "Nursery Cities: Urban Diversity, Process Innovation, and the Life Cycle of Products," *American Economic Review*, 91(5), 1454-1477.
- Ellison, G., & E. L. Glaeser (1997). Geographic concentration in U.S. manufacturing: a dartboard approach. *Journal of Political Economy*, 105(5), 889-927.
- Estache, A. and M. Fay (2007). Current debates on infrastructure policy. Paper Prepared for the Growth Commission.
- Fujita, M. (1988). A monopolistic competition model of spatial agglomeration: differentiated product approach. *Regional Science and Urban Economics*, 18, 87-124.
- Fujita, M., P. Krugman, and A. J. Venables. (1999) *The Spatial Economy: Cities, Regions, and International Trade*. Cambridge, Mass.: The MIT Press.
- Garcia-Mila, T., and T. McGuire. 1993. "Industrial mix as a factor in the growth and variability of state's economies." *Regional Science and Urban Economics* 23:731-748.
- Glaeser, E. L., Kallal, H. D., Scheinkman, J.A., and A. Shleifer. 1992. "Growth in cities." *Journal of Political Economy* 100:1126-1152.
- Government of Uganda (2007). National Industrial Policy: A Strategy for Uganda's Transformation, Competitiveness and Prosperity. Ministry Of Tourism, Trade & Industry ([www.mtti.go.ug](http://www.mtti.go.ug)).
- Henderson, J.V. (2003). The Urbanization Process and Economic Growth: The So-What Question, *Journal of Economic Growth*, 8, 47-71.
- Isard, W. (1956). *Location and Space-Economy*. Cambridge: MIT Press.
- Jarvis A., H.I. Reuter, A. Nelson, E. Guevara. (2006). *Hole-Filled Seamless SRTM Data V3*. International Centre for Tropical Agriculture (CIAT). Available from <http://srtm.csi.cgiar.org>. Downloaded March 28, 2007.
- Lall, S. V., J. Koo and S. Chakravorty (2003). "Diversity Matters: The Economic Geography of Industry Location in India". World Bank Policy Research Working Paper No. 3072.

- Lall, S.V. and T. Mengistae. (2005). "The impact of business environment and economic geography on plant level productivity: an analysis of Indian industry." Policy Research Working Paper 3664. Washington, DC: World Bank.
- Lall, S.V. and H. G. Wang (2007). "Improving the Development Impact of Infrastructure – proposal for a research program" mimeo.
- Mani, M., S. Pargal and M. Huq. 1997. "Is there an environmental 'race to the bottom'? Evidence on the role of environmental regulation in plant location decisions in India." Poverty, Environment and Growth Working Paper No. 15, Washington, DC: World Bank.
- Ministry of Finance, Planning and Economic Development: Republic of Uganda. Draft Estimates of Revenue and Expenditure (Recurrent and Development). 2005-2006.
- Mirachy, W. (1995). Cities and the Product Cycle.: M.I.T. Ph. D. Dissertation.
- Puga, D. (2002). "European regional policies in light of recent location theories." *Journal of Economic Geography*, 2(4), 373-406.
- Rivera-Batiz, F. (1988). Increasing returns, monopolistic competition, and agglomeration economies in consumption and production. *Regional Science and Urban Economics*, 18, 125-154.
- Thomas, T. S. (2007). *Terrain Roughness, 10 km Aggregate, for Africa*. Washington: The World Bank, FEU, SLD.
- Thomas, T. S. (2007). *Travel Time Friction Grid for Africa at 500-meter Resolution*. Washington: The World Bank, FEU, SLD.
- Uganda Bureau of Statistics. 2002. Population and Housing Census: 2002
- Uganda Bureau of Statistics. 2006. Uganda National Household Survey 2005 / 2006.
- Uganda Bureau of Statistics. 2002. Uganda Business Register 2001/2002.
- Uganda Bureau of Statistics. 2002. Uganda Business Inquiry 2000/2001
- USGS Global GIS Database: Africa CD, VMAP level 0. 2001.
- Vernon, R. (1966). International investment and international trade in the product cycle. *Quarterly Journal of Economics*, 80, 180-207.
- World Bank (2004). Project in support of the third phase of the road development program. Project Appraisal Document 27585-UG.
- World Bank (2008). Reshaping Economic Geography. World Development Report 2009. Oxford University Press.
- You, L., S. Wood, U. Wood-Sichra, J. Chamberlin. (2007). Generating plausible crop distribution maps for Sub-Sahara Africa using a spatial allocation model. *Information Development*, Vol.23, No.2/3, p.151-159
- You, L., S. Wood, U. Wood-Sichra. (2007). Generating plausible crop distribution and performance maps for Sub-Saharan Africa using a spatially disaggregated data fusion and optimization approach. *IFPRI Discussion Paper 720*, International Food Policy Research Institute, Washington, DC, USA

## APPENDIX 1: DATA SOURCES

**Travel time grid:** Thomas, Timothy S. 2007. *Travel Time Friction Grid for Africa at 500-meter Resolution*. Washington: The World Bank, FEU, SLD.

UNEP roads and national roads datasets, CIA World Data Bank II, Waterbodies data, and GRUMP/CIESIN global settlement points were used to create friction grid.

**Roads dataset:** UNEP roads are based on the Digital Chart of the World dataset. The World Bank added attributes (primary, secondary, and tertiary) from the 2004 Michelin map series.

**Community points:** Uganda National Household Survey, 2005/2006; Uganda Bureau of Statistics, 2006.

**Education:** Uganda Census Uganda Bureau of Statistics, 2002; Population and Housing Census, 2002

**Manufacturing business points:** Uganda Business Registry, UBoS, 2001/2002.; Uganda Business Register, UBoS, 2001/2002.

**Terrain roughness data:** The CGIAR-CSI (Consortium for Spatial Information, <http://srtm.csi.cgiar.org/>), derived from the USGS/NASA SRTM data, Downloaded March 28, 2007.

**Railroad dataset:** USGS Global GIS Database: Africa CD, VMAP level 0, 2001.

**Powerlines dataset:** UGANDA-AERDP Final Report Annex 1; February 2004.

**Crop Data : IFPRI Spatial Allocation Model; see You, L and Wood, S. (2003) Spatial allocation of agricultural production using a cross-entropy approach. Environment and Production Technology Division Discussion Paper No. 126, International Food Policy Research Institute, Washington, DC.**

**APPENDIX 2: Relative profits from conditional logit model  
(Kampala=100)**

District Name	Relative Profits		
KAMPALA	100.0000	KIBOGA	44.7983
WAKISO	81.8655	NEBBI	43.9336
JINJA	74.7749	KOTIDO	43.6971
MUKONO	66.8287	ADJUMANI	41.9145
KALANGALA	66.3210	KABERAMAIDO	37.9408
MUBENDE	61.6232	BUNDIBUGYO	34.9738
HOIMA	61.2801	KANUNGU	34.6861
KAPCHORWA	58.7859	YUMBE	33.7736
MBALE	57.7578	NYAKAPIRIPIRITI	22.5532
TORORO	57.5950	KISORO	18.1448
LIRA	57.0166	KITGUM	NA
KAYUNGA	56.9183	PADER	NA
KABAROLE	56.9039		
LUWERO	55.9077		
MASAKA	55.6198		
MPIGI	54.3784		
BUSHENYI	54.0480		
MASINDI	53.4652		
MBARARA	53.0022		
PALLISA	52.7676		
BUGIRI	52.5774		
GULU	52.4109		
KASESE	52.3478		
KIBAALE	52.1568		
MOYO	52.1228		
APAC	51.6949		
SOROTI	51.4554		
KABALE	50.8606		
KYENJOJO	50.8025		
BUSIA	50.7307		
IGANGA	50.5119		
SIRONKO	50.2065		
RUKUNGIRI	49.7588		
KAMULI	49.6589		
NAKASONGOLA	48.9634		
RAKAI	48.3818		
KUMI	48.1325		
MOROTO	47.9160		
KATAKWI	47.0133		
MAYUGE	46.8639		
SEMBABULE	46.1921		
ARUA	45.7752		
KAMWENGE	45.4802		
NTUNGAMO	44.9891		